Irrigation Uniformity

Teryl R. Roper
Dept. of Horticulture
University of Wisconsin-Madison

Cranberry production requires a large supply of appropriate quality water. Water is a finite resource and cranberry growers, like all water users, must be wise stewards and not use more than is necessary. Further, increasing energy costs make pumping more water than is necessary a very expensive proposition. Water use can be minimized by having uniform application across each bed. That way some areas are not overwatered in order to provide sufficient water to other parts of the bed.

Sprinkler uniformity is defined as the evenness or similarity in amount of water delivered over or within an area. Ideally, all areas of a bed would receive the same amount of water during the duration of an irrigation event. Sprinkler uniformity is affected by the system design including head and line spacing, the types of sprinkler heads used, and the type of nozzles. Sprinkler uniformity can also change with time as nozzles, heads, and pumps wear, as pipes and joints develop leaks, and if the system is used outside of the design specifications.

Determining sprinkler uniformity and efficiency requires several related measurements. Detailed procedures of how this is to be done are being developed by the Natural Resources Conservation Service in consultation with UW-Extension and WSCGA. These protocols will soon be available through the growers association. This article will serve only to summarize and to present data from a small test that was performed in 2003.

Nozzle wear is a significant source of sprinkler non-uniformity. Nozzles wear as water with grit is pumped through them. Also wires used to unplug nozzles can abrade the opening and thus allow more water to exit that the original design specifies. To check the nozzle opening for wear use the shank of a drill bit of the same size as the nozzle opening. Movement of the drill bit shank should be less than 5-10°. If the bit can move more than this then the nozzle should be replaced. A good management practice would be to replace all nozzles every 2-3 years.

Risers can also contribute to non-uniformity. Risers must be perfectly plumb so that water is sprayed at the same elevation across the bed. Each year as lines are put back into the bed each riser should be checked to ensure that it is plumb and then carefully staked. This is easy to check with a short magnetic bubble level. Riser height can also affect uniformity. Taller risers up to two feet will provide greater uniformity than shorter risers.

The pressure at individual nozzles will change along the length of a line. To check the pressure use a water filled pressure gauge and a pitot tube. With the pump running at operating speed measure the pressure at each nozzle and record the results.

Related to the pressure at the nozzle is the flow at the nozzle. This is easily measured with a hose and a small bucket of known volume. Put the hose over the nozzle and run the hose into the bucket. Measure the amount of time to fill the bucket and record the results.

The critical test used to measure sprinkler uniformity is the catch can test. To do this test containers are placed in a grid with a spacing of 10 x 10 feet. The buckets should have sharp edges and be of uniform size. Coffee cans, ice cream buckets, or 32 oz deli containers work well. The containers should be level in the field. Use stakes to hold them level. Once the buckets are set the sprinklers are turned on and allowed to apply ½ inch of water. The amount of water in each bucket is determined. Uniformity can be calculated from the results.

In 2003 we did a catch can test on a Wisconsin cranberry bed. We worked in an older bed with a two line irrigation system. The lines were about 35 feet from the bed edges and were about 70 feet apart. Heads were 45 feet apart along a line and head placement alternated between lines. The system operated at about 65 psi at a pump engine speed of about 1650 rpm. The nozzle orifice was marked at 11/64 inches. Riser height was 12 inches.

To determine sprinkler uniformity we set up a 15 x 15 foot grid in the bed and placed an empty ice cream bucket at each flagged location. We ran the sprinkler system for 30 to 45 minutes and then measured the amount of water in each bucket. A perfectly uniform system would have identical volumes of water in each bucket. The uniformity coefficient was calculated as:

$$UC = 100\ (1.0 - (\Sigma\ x) \div (m\ n)$$

Where:

UC = Uniformity coefficient
n = number of cans measured
m = mean value of all observations
x = the deviation of each observation from the mean
Σ x = the sum of the deviations from the mean

Without making any changes to the system we ran the pump for 30 minutes then measured the amount of water in each bucket. The results of this test are shown in Figure 1. The location of the sprinklers is clearly evident in the figure. We had a slight breeze blowing across the beds and that shows in the lack of water in the buckets at position 10. The uniformity coefficient for system was 51%.

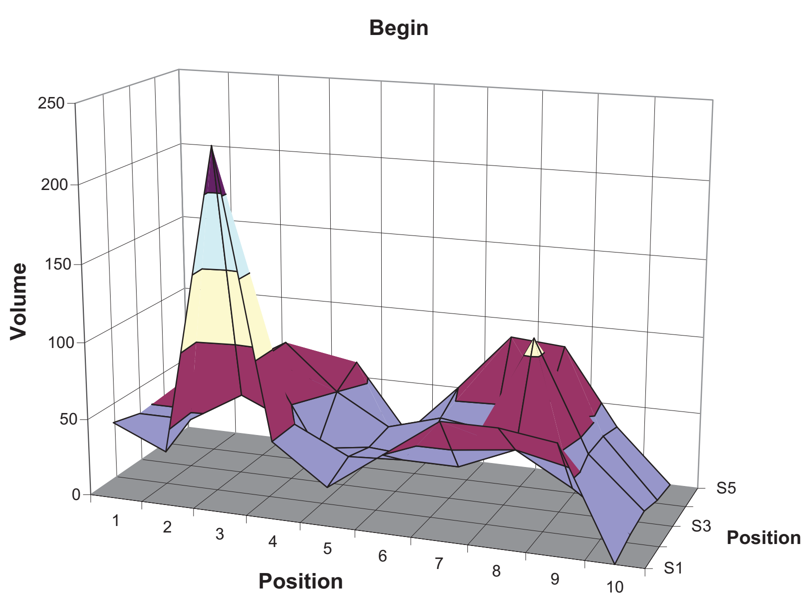

Figure 1. Volume of water per bucket in a 15 x 15 foot grid pattern before any changes were made to the system.

Nozzle replacement. Our first upgrade to the system was to replace the worn nozzles with new ones of the same size. The old nozzles had worn a little bit and they had been cleaned of debris by inserting a wire through the nozzle and this had scratched the openings. We then ran the sprinkler system for 45 minutes and measured the amount of water in the buckets again. The results of this test are shown in Figure 2. We ran the system 15 minutes longer this time and that increased all values somewhat. However, notice that the surface is much flatter. The uniformity coefficient for the system with new nozzles was 66%; a substantial improvement.

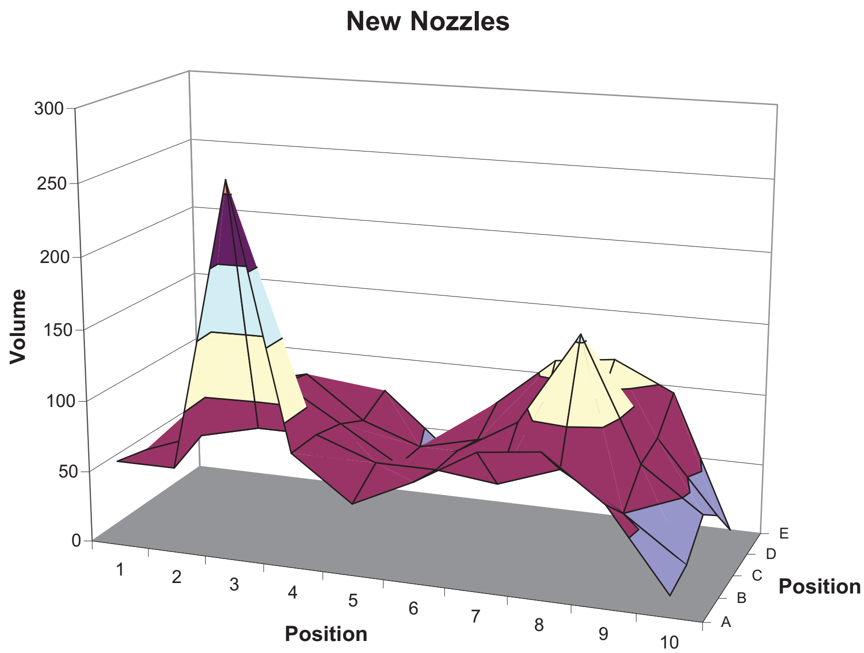

Figure 2. Volume of water per bucket in a 15 x 15 foot grid pattern after nozzles were replaced with new ones of the same size.

Riser Height. Our next upgrade was to increase riser height from 12 to 18 inches. We also staked the risers and made sure they were plumb using a spirit level. The existing risers were not completely plumb so water distribution was not completely even around their coverage area. We ran the sprinklers for another 45 minutes and measured the water caught again. The results are shown in Figure 3. Using taller risers evened out water distribution a little more, but the uniformity coefficient increased only a couple of points to 68%.

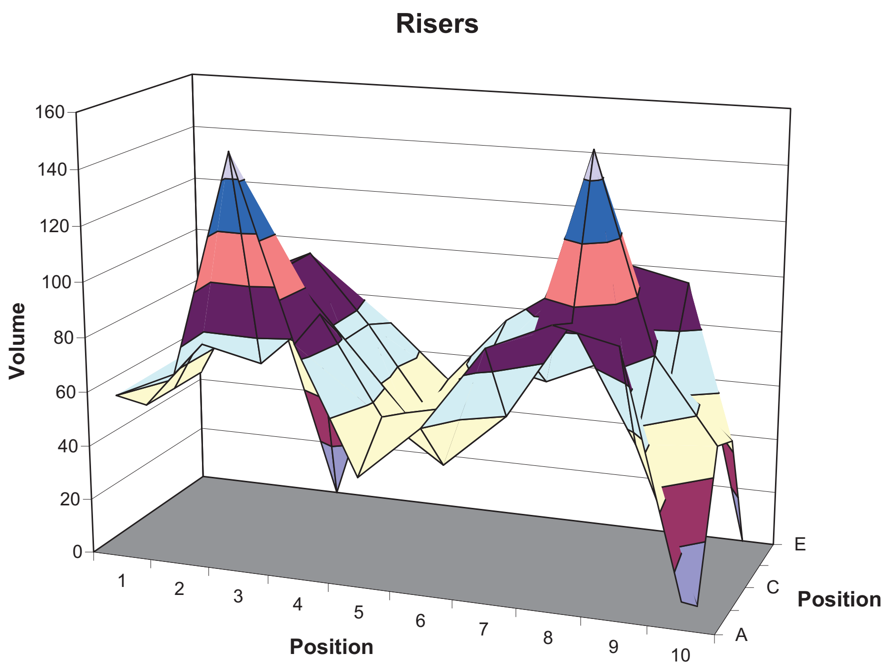

Figure 3. Volume of water per bucket in a 15 x 15 foot grid pattern after nozzles were replaced with new ones of the same size and rise height was increased from 12 to 18 inches.

Three line system. We were then able to obtain funding to replace the irrigation system in this bed with a three-line system using high uniformity sprinklers. We ran our test again with the buckets in the same positions as before. The uniformity coefficient for this configuration was exactly 80%. The results are shown in Figure 4. Clearly the uniformity is higher. The uniformity would have been higher had we run the system longer. Further, some of the buckets were tipped and if they had been perfectly upright our results would have been more accurate.

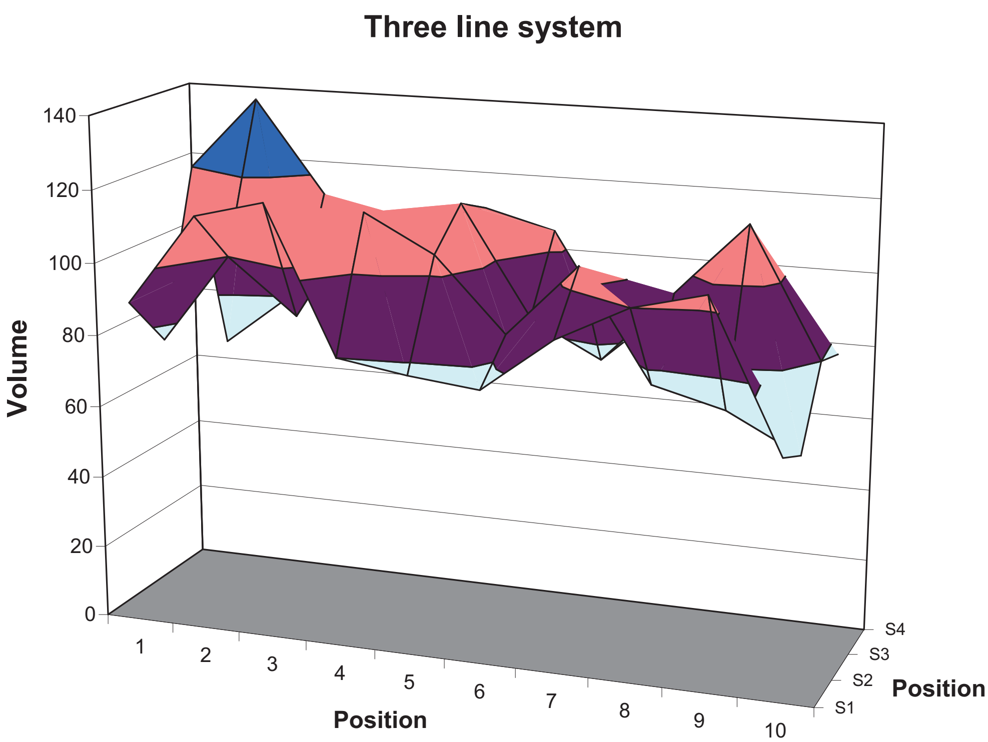

Figure 4. Volume of water per bucket in a 15 x 15 foot grid pattern after the system was upgraded to a 3 line system with high uniformity nozzles.

Conclusions

1. The greatest improvement in sprinkler uniformity at the lowest cost was nozzle replacement.
2. The older two line system had to be upgraded to three lines with closer head spacing to achieve a uniformity of 80%.
3. Increasing riser length gave marginal improvement
4. Substantial water saving can be realized simply by replacing worn nozzles.

We thank Mike Moss and his staff at Elm Lake Cranberry Co. for their assistance in this project. NRCS and WSCGA graciously provided funding to purchase the upgraded equipment.